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Ramirez Hernandez, Tabea; Kreye, Melanie; Eppinger, Steven

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Tabea Ramírez Hernández (tarah@dtu.dk)
Department of Management Engineering, Technical University of Denmark, Kongens Lyngby, Denmark

Melanie Kreye
Department of Management Engineering, Technical University of Denmark, Kongens Lyngby, Denmark

Steven Eppinger
Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

Abstract

Developing Product-Service Systems (PSS) is uniquely challenging in terms of both the offering and the development process due to the combination of product and service components. This paper investigates the applicability of agile and scrum method, having originate in the software industry, to the development of PSS to address these challenges in practice. Based on a combination of agile and servitization literature, this paper offers a conceptual framework detailing the applicability of four agile elements (application, management, technical, personnel), and nine scrum elements in three groups (events, artefacts, roles). This research contributes to the servitization literature by extending the knowledge on PSS development and deriving suitable management practices.

Keywords: Agile, Scrum, Product-Service System, Project Management

Introduction

Manufacturers are increasingly seeking to servitize their business through the provision of Product-Service Systems (PSS), compound offerings of products and services. This trend promises the provider high gains including closer customer contact, stable revenue streams, and higher profit margins (Isaksson et al., 2009). However, by far not all manufacturers experimenting with the concept of PSS are able to harvest these benefits. Indeed, the history of servitization shows many examples of PSS development projects, which fail already during the development and never even reach the market. In response, a stream emerged in the academic servitization literature, which discusses in particular the challenges of PSS development.

Core challenges for manufacturing firms in the development of PSS often arise because of the radical nature of the final offering (Baines et al., 2017), the systemic complexity of parallel development of the product and service (Trevisan and Brissaud, 2017), and the difficulty of project execution (Morelli, 2006). Here challenges can arise in the course of defining and testing intangible service elements, as many services are

produced and consumed simultaneously (Lankhorst, 2012). In addition, manufacturers often have to manage the systemic complexity of developing not only the product and the service distinctly, but as a system. Here manufacturers often lack knowledge regarding the diverse interfaces in this systemic integration (Trevisan and Brissaud, 2017). Lastly, uncertainty arising from the unpredictability of the competitors' actions, the precise customer needs, or other macro-economic changes can impede the development (Kreye, 2017). In short, the development of PSS is often characterized through high uncertainty and complexity (Ramírez Hernández et al., 2018).

While contributions in the servitization literature investigated the challenges of PSS development, no suitable solution has been identified up to date. The PSS development methodologies offered today (Dingsøyr et al., 2012; Vasantha et al., 2012a) are still strongly oriented on the traditional stage gate approach (Aurich et al., 2006; Vasantha et al., 2012b; Weber et al., 2004). Academic literature has however reflected upon uncertainty management in new product or service development. As such, Rice et al (2008) proposed the use of more "agile" methods under circumstances of high uncertainty, and more "staged" methods, under circumstances of low uncertainty. Short development cycles through testing of assumptions about uncertain conditions and incorporating these learnings into the development project to plan the next short iteration are used to navigate these uncertainty conditions. Moreover, Boehm and Turner have investigated the concept of agile further and identified the basis of agile, i.e. when agile works most successful. They distinguish four elements; Application, Management, Technical and Personnel, and discussed their variance for the optimal application in agile. These four elements of agile represent a guidance for *where* to apply agile.

Further, the concept of agile manifests itself in several methods, of which scrum is one of the most mature and widely applied (Dingsøyr et al., 2012). It is divided into three groups; events, artefacts and roles, with three elements each (Cooper and Sommer, 2016a; Schwaber and Sutherland, 2017). The events include the sprint planning and sprint, the daily scrum, and the review and retrospective meeting. The artefacts contain the product backlog, the sprint backlog, and the increment. The roles are distinguished into the product owner, the scrum master, and the scrum team. These nine elements of scrum provide guidance on *how* to apply agile.

While the body of knowledge about agile (and its manifestation in scrum) has grown substantially in the field of software, its application outside this realm is still nascent. Specifically, the applicability of agile and scrum in contexts such as PSS development is promising, yet underexplored. Accordingly, we ask the following research question to close this gap:

Which elements of agile and the scrum methodology are applicable to the development of Product-Service Systems?

Based on the analysis of existing servitization and agile literature, we offer a conceptual framework detailing the above-mentioned four elements of agile and nine elements of scrum, in terms of their applicability in PSS development. While describing these elements of agile and scrum is not in itself a new contribution to the literature, assessing their application and adaptation to the PSS development context contributes to theory building in the field of servitization and agile.

Research Design

To answer the research question, we conducted an exploratory literature review based on contributions in the field of agile and servitization. The aim of the literature review was

to create a rich understanding of the state-of-the-art literature and to comprehend the applicability of agile and scrum to the PSS development context. The literature review is based on contributions identified through a keyword search in the search databases including Scopus and Web of Science.

The review of the agile literature included search strings derived from the following keywords: "agile" (Boehm and Turner, 2003; Dingsøyr et al., 2012; Moran, 2015), "agile development" (Conforto et al., 2014; Nerur and Balijepally, 2007), "scrum" (Dybå and Dingsøyr, 2008; Schwaber and Sutherland, 2017), "agile service development" (Cocca et al., 2015; Lankhorst, 2012), "agile product development" (Cooper and Sommer, 2018; Karlström and Runeson, 2006). Similarly, the review of the servitization literature was conducted using keywords "Product-Service System" or "PSS" (Beuren et al., 2013; Mont, 2002; Tukker, 2004), "integrated solution" (Storbacka, 2011), "bundled services" (Schmenner, 2009), "servitization" (Baines et al., 2017; Díaz-Garrido et al., 2018), "PSS development" (Aurich et al., 2006; Wallin et al., 2015; Wuest and Wellsandt, 2016), and "new service development" (Papastathopoulou and Hultink, 2012; Santos and Spring, 2013). Based on the initial findings, we refined and combined the keywords further in the course of the literature review.

The literature review revealed the need to differentiate between the application of agile as a concept and its manifestation in a specific method (Boehm and Turner, 2004). Agile as a concept provides guidelines of a general setting under which agile is best applied. Boehm and Turner, (2004) summarized a framework which distinguished four elements as the general basis of agile: Application, Management, Technical and Personnel. The *Application* of agile details that it unfolds its full potential in volatile conditions through rapid value creation in small teams. The *Management* relies strongly on intense customer involvement in the project, with qualitative control mechanisms and strong utilization of tacit, interpersonal knowledge. The *Technical* element details simple designs, which are easily refactorable in short increments with test cycles, as well as prioritized requirements, which are evolving continuously. Lastly, agile relies strongly on *Personnel* who are 100% dedicated to the project, working co-located and with a culture of empowerment. These four elements of agile constitute the overall applicability of agile to a certain setting and thus form the basis for our discussion in the PSS development context.

The manifestation of agile finds its way into several methods in practice. One of the most applied and researched methods is scrum, which describes an iterative development process with incremental value delivery. Although scrum is often modified to fit the particular situation, for the purpose of the present research we will refer to the original form derived from the software development (Schwaber and Sutherland, 2017). It distinguishes events, artefacts and roles, with three elements each (Cooper and Sommer, 2016a; Schwaber and Sutherland, 2017). The events include the sprint planning and sprint, the daily scrum, and the review and retrospective meeting. The *sprint planning* is an event in which the work packages for the upcoming development are planned. The *sprint* represents the subsequent intense development period of usually 1-4 weeks duration, in which the previously defined work packages are created. The *daily scrum* represents a stand-up meeting on each day of the sprint, in which each team member reflects on the progress of the developments, as well as potential problems. After the sprint a *review and retrospective* meeting is held, in which the team reflects upon the developed work, as well as the process through which it was developed.

The artefacts are the product backlog, the sprint backlog, and the increment. The *product backlog* represents the prioritized list of requirements, which is continually updated to incorporate the learnings of each sprint. The *sprint backlog* is the amount of

work chosen by the development team to be executed in the course of one sprint. Unlike the product backlog, the sprint backlog requirements do not change during the sprint. The *increment* is the outcome of the development work in the course of one sprint. It is used in the review and retrospective meeting to test and seek feedback from customers and stakeholders. Based on this feedback, the product backlog is re-prioritized.

The roles include the product owner, the scrum master, and the scrum team. The *product owner* is the person responsible to update and manage the product backlog to achieve the desired product. The *scrum master* is the process owner and facilitates the team in the application of scrum, as well as the removal of impediments of the development project. Lastly, the *scrum team* is responsible for the actual development and consists of a cross-functional, fully dedicated team.

While the application through reduction of uncertainty promises a beneficial application of agile and scrum in PSS, it is however important to note that PSS also differ from the origin of agile in pure software development. While software is intangible, infinitely divisible, and easily refactorable, this is not true for PSS. Particularly the product element of PSS is tangible, most likely not infinitely divisible, and, once produced, only refactorable under additional costs. The service element on the other hand is intangible and often easily refactorable (or adjustable to the customer conditions), but can only fully be tested in the field as it is produced and consumed simultaneously. As such, it remains to be investigated which elements of agile and scrum can be applied to PSS development to address the strong challenges during the development.

Conceptual Framework: Applicability of Agile and Scrum in PSS Development

To answer our research question, we utilize a conceptual framework combining the four bases of agile defined by Boehm and Turner (2003) with the nine elements from the events, artefacts and roles described by (Cooper and Sommer, 2016a; Schwaber and Sutherland, 2017). We apply this framework to assess the suitability and adaptation of agile and scrum in the specific context of PSS development.

Agile Elements

(1) The Application

The first basis of agile, the *Application*, is highly similar to the original description, as regularly also in PSS development, volatile conditions have to be managed and customer needs addressed. In addition, PSS often possess systemic complexity between the product and the service part, which implies that scrum needs to be scaled to coordinate the separate developments of several components (e.g. service and product components) in parallel through e.g. “scrum-of-scrum” (Dingsøyr et al., 2018). Overall, no adaptation to the element of *Application* to PSS development is needed.

(2) The Management

For the basis of *Management*, small adaptations have to be considered in the PSS context. The development of PSS may be highly customer focused and involve a close collaboration or even co-creation with the customer (Kristensson et al., 2008; Vargo and Lusch, 2008). It also often relies strongly on communication and team collaboration (Wolfenstetter et al., 2015). However, large and traditional enterprises moving towards servitizing their business through offering PSS are likely unable to abandon their legacy plan-based and KPI-driven development and solely rely on qualitative control mechanisms and tacit, interpersonal knowledge (Boehm and Turner, 2005). This organizational resistance to agile may be overcome through change management

practices. As such, the agile basis of *Management* is generally applicable to PSS development, calls however often for additional change management practices.

(3) The Technical

The *Technical* basis of agile partly conflicts with the characteristics of PSS. Some PSS can possess a high systemic complexity, which arises from the combination of (tangible) product and (intangible, process-focused) service elements. This combination creates high interdependencies to ensure operability of the Product-Service System. As such, the service has to be tailored to the product characteristics, and the product design should consider the service-ability (Trevisan and Brissaud, 2017). Due to this strong limitation, literature proposes a more structured approach such as the application of e.g. the Scaled Agile Framework (SAFe) (Leffingwell et al., 2013), to coordinate the integrated development. In addition, the product element is not as easily refactorable as pure software code due to its tangibility (Conforto et al., 2014) and thus, limits the optimal operation of agile as suggested by the *Technical* basis. However, PSS generally complies with the struggle of volatile requirements and the need for testing the developed increments (Morelli, 2006; Wolfenstetter et al., 2015) mentioned for the *Technical* basis. Concluding, while some parts of PSS development characteristics comply this *Technical* basis, others call for strong adjustments.

(4) The Personnel

Lastly, the agile basis of *Personnel* is again partially applicable to PSS development. While PSS development thrives on cross-functional teams with high customer engagement (Wolfenstetter et al., 2015), traditional manufacturers regularly struggle with full staffing of the employees on the project. In addition, large organizations are often regionally spread out, which hampers the ability to develop with co-located team members (Conforto et al., 2014). Furthermore, traditional manufacturers may struggle with the transition from a hierarchical towards a flat and empowered culture (Paasivaara et al., 2018). As such, in principle PSS development complies with the *Personnel* basis of agile; in practice however, manufacturers may need to adapt agile to operate within the existing structures of the organization.

Scrum Elements

(1) Sprint and Sprint Planning

The first event consists of the *sprint planning and sprint*. The agile literature has already investigated the applicability of the sprint planning and sprint to new service development as well as to new product development in separation. In new service development, the service may be developed through planned, time-boxed iterations and short feedback cycles with the customer (Cocca et al., 2015; Lamberth-Cocca and Meiren, 2017; Lankhorst, 2012). In new product development however, the *sprint planning and sprint* is not as easily applied. Due to the tangibility of the product, many teams struggle to decompose the physical product into several fully-functional sub-products which are developed in sequential, periodic sprint cycles. As such, not every *sprint planning and sprint* may be able to create a functional sub-product that can be demonstrated to the customer as originally defined. Rather, several *sprint planning and sprints* may be required to deliver the concept, the CAD-model or drawing, the testable component, an integrated prototype, and finally the product (Cooper and Sommer, 2016b). In addition, the systemic complexity of integrating product and service elements calls for a more structured approach to coordinate the interrelation between them (Morelli, 2006; Wolfenstetter et al., 2015). To answer these limitations of PSS development to a pure *sprint planning and sprint*, literature proposes a more linear agile process, called the Agile-Stage-Gate hybrid (Cooper and Sommer, 2016a). Here the linear development

mode and the periodic control of the stage gate process are merged with agile sprints in between the gates.

(2) The Daily Scrum

The second event, the *daily scrum*, is intended to foster a short, intense exchange of the most critical information regarding the development project (Paasivaara et al., 2012). PSS development frequently also builds upon intense collaboration between the team members to coordinate the systemic complexity (Trevisan and Brissaud, 2017). The daily scrum is thus easily transferrable to the PSS development context and may even enhance the collaboration.

(3) The Retrospective and Review Meeting

The third event of scrum is called the *retrospective and review meeting*. Here lessons learned are implemented already in the course of the development project. In contrast, in traditional PSS development literature, the revision of the PSS developed and a reflection on the underlying process is conducted after finalizing the PSS (Aurich et al., 2006; Vasantha et al., 2012b). Thus, the lessons-learned are implemented in the subsequent development project. Given the often high degree of uncertainty in PSS development, fast learning and adaptation is not only transferrable, but also strongly recommendable.

(4) The Product Backlog

The first artefact of scrum is the *product backlog* and comprises a prioritized list of features the final offering should have. It represents the counterpart to the detailed requirement specifications in PSS development (Aurich et al., 2006). However, the product backlog of scrum is a tool which acknowledges the degree of uncertainty connected to the requirements and is thus constantly updated (Schwaber and Sutherland, 2017). Due to the uncertainty in the context of PSS development (Morelli, 2006), the application of ongoing adaptable requirements can be recommended. As the most important items of the product backlog assure the most important items for the creation of customer value (Schwaber and Sutherland, 2017), the application of the product backlog (in combination with iterations collecting customer feedback) enhances customer satisfaction (Cooper and Sommer, 2018). Since PSS often aim to create strong long-term customer relationships (Beuren et al., 2013; Visnjic et al., 2016), the application of the product backlog may not only reduce uncertainty, but also strengthen the customer relationship (and satisfaction).

(5) The Sprint Backlog

The second artefact is the *sprint backlog*. The sprint backlog is the selection of the most important requirements to be developed in one sprint and remains unchanged in the course of this sprint. At its core, the sprint backlog provides the team with the necessary structure and implies a small plan-based approach: after planning the requirements, the actual development is carried out. Traditional PSS development methodologies follow this logic (just at a larger scale) (Aurich et al., 2006; Vasantha et al., 2012b). Accordingly, if the structure of periodic sprints is to be used, the sprint backlog should be easily transferrable to PSS development.

(6) The Increment

The third artefact is the *Increment*. This is the complete, functional, testable and releasable outcome of a sprint (Schwaber and Sutherland, 2017). Although in the context of new service development, the increment could be easily applied (Cocca et al., 2015; Lamberth-Cocca and Meiren, 2017; Lankhorst, 2012), in the context of new product development the original definition of the increment is troublesome (Cooper and Sommer, 2018; Karlström and Runeson, 2006). As elaborated before, the physicality of the product hampers the development complete and functional product increment (Karlström and Runeson, 2006). Research from the use of scrum in product development

proposes here a redefinition of the increment towards "a complete and testable deliverable", which can thus also be applied in the context of PSS development (Cooper and Sommer, 2016b).

(7) The Product Owner

The first role is the *product owner*. The product owner is responsible for the prioritization of the product backlog and the stakeholder management to ensure management support (Schwaber and Sutherland, 2017). In PSS development, this role requires a strong understanding of both the product and the service elements, as the product owner must continually re-prioritize the requirements for the entire project. While the role as such is easily applicable to PSS development, in practice it may require senior experts to execute this role (Dikert et al., 2016).

(8) The Scrum Master

The second role is the *scrum master*. The scrum master is responsible for the correct execution of the scrum methodology and the removal of obstacles the development team may encounter (Schwaber and Sutherland, 2017). In the context of PSS development, organizational resistance can arise as both, the PSS offering (Visnjic et al., 2016) and the scrum process (Dikert et al., 2016), may be novel to the organization. Therefore focus should be laid on a properly trained scrum master with strong stakeholder management capabilities (Boehm and Turner, 2005). Overall, the scrum master should be easily applied to any PSS development project.

(9) The Scrum Team

The *scrum team* is defined as the last role of the scrum methodology. Here, in the original definition the team should be fully dedicated, co-located, empowered and cross-functional (Schwaber and Sutherland, 2017). As mentioned in the *Personnel* element, full dedication, co-location and empowerment can be challenging for traditional manufacturers. The scrum methodology specifies however, that the full potential of scrum can only be reached if the elements are kept as defined – specifically the fully dedicated and co-located team (Boehm and Turner, 2005). Weakening of this requirement would strongly impact the team's ability to learn and adapt fast. Accordingly, an adaptation for this challenge could be to apply scrum only to highly critical projects of PSS development with high uncertainty. In short, the application of the scrum team in its original sense poses challenges to traditional manufacturers, but should not be compromised when applied in the PSS context.

Figure 1 summarizes our conceptual framework. In sum, the concept of agile is generally applicable to the PSS development context. While some elements are fully or through smaller adaptations directly transferable to PSS development, the *Technical* element requires major adaptation in the PSS context. The same accounts for the application of agile through the method scrum. Some elements are easily transferrable to the PSS development context, while others need major adaptations.

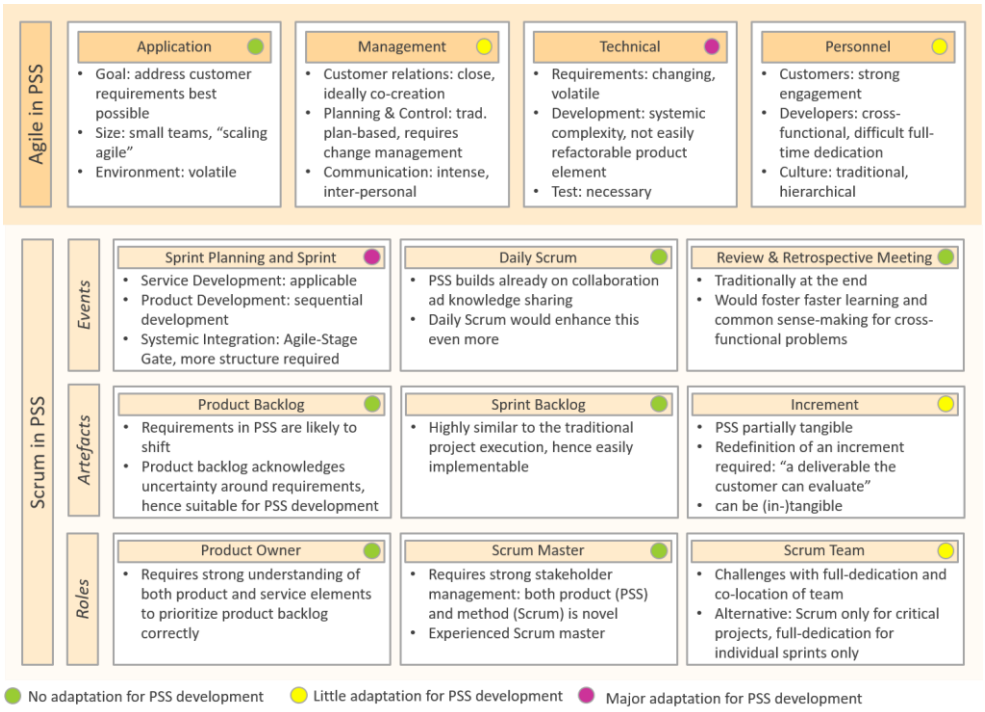

Figure 1 Framework illustrating the application of agile and scrum in PSS development

Implications and Conclusion

In this paper, we investigate the question of which elements of agile and scrum are applicable to the development of Product-Service Systems. Through an exploratory literature review, we derive a conceptual framework based on the literature streams of agile and servitization. This framework distinguishes four elements of agile, and nine elements of scrum, which are each discussed in the context of PSS development. While the concept of agile and scrum have already been discussed in depth in the software development literature, we investigate the expansion of its application areas to the context of PSS, which has not been discussed previously.

This framework contributes to the servitization literature by discussing a theoretically founded, alternative development approach of PSS through the application of agile and scrum. Through uniting the bases of agile with a method of implementation, scrum, we help solving the challenges during the development of PSS due to its often volatile and uncertain conditions.

This paper also contributes to the agile literature by expanding its areas of application. Through the theoretical discussion of the application of agile and scrum in PSS development, we test its functionality from the original realm of software. We reveal its strengths and limitations in the context of PSS, and expand the discussion through the proposition of potential adaptations needed for this application.

For managers, this research holds several implications. The proposed framework raises awareness to the distinct circumstances of PSS development. It provides managers further with a guideline on when to apply agile management methods, and how scrum can be utilized in the context of PSS development. It also gives suggestions on how to adapt scrum specifically to the PSS development setting.

This research bases on the retrospective and conceptual analysis of academic literature, which represents a major limitation for the validity of the framework. Further research is planned to advance the insights from this framework through case-study research.

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